WEST AFRICAN COCOA RESEARCH INSTITUTE

QUARTERLY PROGRESS REPORT

No. 55

TAFO, GHANA.

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FIFTY-FIFTH QUARTERLY REPORT

JULY-SEPTEMBER, 1959

Any results recorded in this report should not be accepted as conclusive inasmuch as the report contains interim information only. More complete results are published in W.A.C.R.I. Technical Bulletins and elsewhere.

SENIOR STAFF

Director	J. Lamb
Scientific Assistant to Director	G.A. Jones (on leave)
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Accountant	H.J.S. Mill
Assistant Accountant	J.N.A. Hyde (on leave 23/7/59-21/8/59)
Office Assistant/Librarian	D.J. Ellis (Miss)
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	P.F. Entwistle (on leave)
	M.R. Smith
	K.B. Armstrong
Division of Pathology	J.W. Blencowe
	A.L. Wharton
	A.A.F. Brunt (returned from leave 26/8/59)
	P.D. Turner
	A. Attafuah (on scholarship in U.K.)
Division of Botany	D.R. Glendinning
	R.G. Hurd
Division of Chemistry	R.H. Kenten (returned from leave 26/8/59)
	R.K. Cunningham (on leave)
Division of Agronomy	R.W. Smith (on leave)
	T.H.R. Hall
Statistician	C. de Jonge (on leave 30/7/59)
Laboratory Technicians (Electronics)	A.J.H. Arnold (returned from leave 4/9/59)
(Spectrography)	J.C. Burridge (on leave)
Plantation Manager	H.W.S. Allison (on leave 30/7/59)
Maintenance Engineer	G.O. Hayward
Works Superintendent	E.K. Berko
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Station Manager	S.E. Ntim-Kwafo
Medical Officer	P.K.K. Knudsen (on leave 24/8/59)
IBADAN SUB-STATION	
Deputy Director (Nigeria)	T.W. Tinsley (returned from leave 22/9/59)
Entomologists	R.G. Donald
	C.K.H. Martini
Pathologists	J.M. Thresh (returned from leave 8/7/59)
	D. Kay
Agronomist	J.F. Longworth (on leave 12/8/59)
Mycologist	E.C. Hislop
Plantations Officer	W. Rides (arrived, on secondment, 1/7/59)
WEST AFRICAN FUNGICIDES RESEARCH UNIT	
Chemist	P.O. Park

STAFF MATTERS

Messrs. H.L. Pugh, A.A.F. Brunt, A.J. Arnold, R.H. Kenten, J.M. Thresh and Dr. T.W. Tinsley returned from leave during the quarter. Mr. J.F. Longworth and Dr. P.K.K. Knudsen went on leave in September. Messrs. H.W.S. Allison and C. de Jonge also proceeded on leave in July and Mr. C. de Jonge returned on 4th September, 1959.

Mr. A. Attafuah was awarded a scholarship by the Ghana Cocoa Marketing Board and proceeded to the United Kingdom in September to follow a course of study at Reading University.

Dr. T.W. Tinsley and Dr. J.W. Blencowe attended the IXth International Botanical Congress in Montreal during August. Dr. Tinsley later visited Washington, Miami and Costa Rica at the invitation of the American Cocoa Research Institute to study cushion gall disease and to advise on cocoa quarantine procedure. On his return from leave Dr. Tinsley visited the Belgian Congo at the invitation of the Belgian Colonial Government.

Messrs. Kay and Hislop visited Tafo during the quarter, the former on two occasions, one visit being of five weeks duration.

Mr. W. Rides joined the staff of the Institute Sub-Station as Plantation Officer on secondment from the Ministry of Agriculture and Natural Resources, Western Region, on 1st July.
A possible site for a field research station near Ibadan has been surveyed and the boundaries demarcated. A search for a suitable site for waterworks within the area is being conducted.

VISITORS

Sir James Robertson, Governor-General of the Federation of Nigeria, accompanied by Lady Robertson, Lady Jackson and Captain R.E. Hartop, A.D.C., visited the Institute in July. Other visitors included Mr. D.L. Brown, Director, Mars Ltd., Mr. Chinwuba of the West African Maize Research Unit (Nigeria), Mr. & Mrs. Israel Goldstein of New York (U.S.A.), Mr. H.A. Walker, Ghana Meteorological Services and Mr. E.C. Quist-Therson, Permanent Secretary, Ministry of Food and Agriculture.

The Station was visited also by a party of Foreign Ambassadors in Ghana, M.G. Merny, accompanied by six students from the Ivory Coast, Mr. Walker, Lyons & Co. Ltd., Mr. J.H.E. Johnson, Pembroke College, Cambridge University, Prof. Friedensbury, a German Parliamentarian, Mr. W. Allan, Land-use Research Worker, sponsored by Manchester University and the Rockfeller Institute, (U.S.A.), Dr. K.E. Johnson, I.C.A. (Nigeria) and Dr. P.A. Kent, Chemist, Gill & Duffus Ltd.

Members of the Imperial Defence College, representatives of the Chocolate Manufacturers' Association of America, and M.G. Merny with a party of French post-graduate students visited both Tafo and the Ibadan Sub-Station.

Other visitors to the Sub-Station have included Lord and Lady Perth, four members of the German Parliament, accompanied by the German Consul in Nigeria, representatives of two British Chocolate manufacturing firms and of insecticide and fungicide manufacturers.

The work of the Sub-Station was explained to a party of Nigerian Agricultural Students, and another of Lagos members of the Nigerian Field Society. Mallam Rogun, an Assistant Agricultural Superintendent from the Northern Region spent three days seeing work on cocoa.

AGRONOMY DIVISION

TREE MORTALITY - OLD STATION FARM

Trees removed during the quarter due to swollen shoot infection and other causes are tabulated below:

Month	Trees Destroyed		Total	No. of Seedlings Removed
	Swollen Shoot	Undiagnosed		
1959				
July	34	2	36	58
August	65	5	70	97
September	35	-	35	37
Total	134	7	141	192

AMAZON SEED SUPPLY:

19,032 pods were sent to Nigeria during the quarter, 1,218 in July, 5,439 in August, 12,375 in September.

SQUARE MILE:

Considerable increase in yield in all the experimental plots has been experienced.

The incidence of Black Pod infection in the Upper Amazon Multiplication was higher than in 1958. Twenty-two per cent of the pods harvested were discarded as compared with less than 5% in the same period of the previous year.

Yield in the various experiments under the care of the Division compared with the same period of last year has shown an overall increase of 50%.

IRRIGATION TRIAL:

Height measurements and flush counts were made regularly. The seedlings have made remarkable growth.

METEOROLOGY:

Rainfall in inches and number of wet days for the quarter compared with the past 21-year means:

Month	1959		Past 21-year means	
	Rainfall (in.)	Wet days	Rainfall (in.)	Wet days
July	10.83	21	5.51	31.6
August	1.90	7	2.44	12.7
September	6.11	14	5.91	14.5
Total	18.84	42	13.86	40.8

PATHOLOGY DIVISION

VIRUS RESEARCH

Effect of virus infection on growth and yield of Amelonado and Amazon cocoa

In the Experiment A4 on the effects of five different virus isolates on the growth and yield of Amelonado cocoa (Q.R.53), the treated plots are beginning to take on the appearance of natural virus outbreaks. Six months after graft inoculation between two-thirds and three-quarters of the plants infected with virus of the swollen-shoot group had shown symptoms, as had half of the plants infected with cocoa mottle leaf (Kpeve) virus. Only 4% of the plants infected with the Bisa virus, which causes only stem swellings, were visibly infected.

In the Experiment H2 where the effects of virus infection on both Amelonado and Amazon cocoa growing with and without shade and in the presence and absence of added fertilizer are being studied, the appearance of symptoms has been rather slower. Half of the Amelonado trees and one-seventh of the Amazon trees are visibly infected. Symptom appearance was much more rapid without shade on the Amazon trees, but there was no parallel effect on Amelonado. Symptom appearance has not as yet been affected by application of fertilizer. Neither virus-infection or fertiliser application affected the 1959 mid-crop yields.

The collaborative experiments with the Ghana Division of Agriculture on the capsid-spraying of virus-infected cocoa have received the first insecticide treatment. Fifty-six plots have been established at four centres, and yields are being recorded on about 10,000 trees. Some plots have responded

spectacularly to the clearing of the undergrowth and weeds in areas of neglected infected cocoa. In some of the more exposed sites the infected trees have deteriorated more rapidly than had been expected. For instance at Ampem, on the southern margin of the Afram Plains, 96 of the 1,600 trees died during the first six months; rather more than half of these were on plots that had been sprayed.

Further experiments on the growth-rate of virus-infected cocoa seedlings have confirmed that multiple infections with un-related virus isolates have additive effects, while multiple infections with related strains do not.

Results abstracted from data collected in 3 such experiments are tabulated below:

ISOLATE	PERCENTAGE REDUCTION RELATIVE TO HEALTHY CONTROLS			
	TOTAL FRESH WT.	TOTAL DRY WT.	HEIGHT	LEAF AREA
New Juaben	79.2	77.4	48.9	71.7
Bosomuoso	84.7	82.5	49.7	78.3
New Juaben & Bosomuoso	87.0	84.7	52.0	80.5
Nkawkaw	16.6	27.8	17.6	13.3
Mampong	31.3	34.7	29.9	31.9
Nkawkaw & Mampong	47.0	61.5	34.1	42.1
AD 14	53.4	57.6	29.0	45.8
AD 191	39.5	41.8	17.6	32.9
AD 14 & AD 191	51.6	51.7	28.7	44.9

Host Range Investigations

More trees known to be susceptible to cocoa viruses have been examined soon after felling (see Q.R. 51, p.6). Virus infection was not demonstrated in any of the trees tested.

STUDIES ON BLACK POD DISEASE

Resistance and tolerance

The Division of Agriculture have concluded agreements with the owners of the six-acre site at Mpraeso selected for the trial of varieties bred for resistance to black-pod infection. Establishment is under the direction of the Officer-in-charge, Pankese Cocoa Station. The land is being cleared of all standing trees and will shortly be ready for the planting of temporary shade. Delivery of hand-pollinated pods from Tafo to Pankese has started.

Strains of Phytophthora palmivora

Collections of diseased tissue have been made from a number of widely-spaced localities in the Western Region of

Nigeria. Isolates have been obtained at Tafo from diseased pods from Agodi, Akure, Araromi-Loji, Ikeji, Ikom, Illaro, Illesha, I.N.A., Isho, Ondo, Oni, Umuahia and Uvbe. Leaves with tip necrosis, yielding P. palmivora, were collected at Umuahia. Preliminary observations have confirmed earlier findings that there are, at least, two distinct 'strains' of P. palmivora occurring in Nigeria.

Fungicide Spray Control Trials

Attempted control of black-pod disease by use of light mineral oil has continued. A steady rise in the amounts of the disease in both treated and untreated plots has occurred. Cumulative totals at the harvest on 23rd September, 1959, were as follows:

Spacing	Replicate No.	Total Pods	No. black-pods	% black-pod	
8 x 8	3	1471	246	16.7	Treated
8 x 8 P	2	964	120	12.4	
10 x 10	1	526	75	14.3	
10 x 10 P	4	1408	137	9.7	
12 x 12	2	425	42	9.9	
12 x 12 P	3	1182	69	5.8	
TOTAL	15	5976	689	11.5	
8 x 8	2	895	252	28.2	Control
8 x 8 P	3	1139	175	15.4	
10 x 10	4	2499	441	17.6	
10 x 10 P	1	697	41	5.9	
12 x 12	3	2023	335	16.6	
12 x 12 P	2	445	15	3.4	
TOTAL	15	7698	1259	16.4	

P = pruned to 1st jorquette.

Galls of Cocoa in Ghana

Following reports in 1958 of the rapid spread of "cushion-gall" disease on cocoa in Costa Rica, and the epiphytotics in Nicaragua and Colombia, a survey was made in Ghana to determine if such a potentially important disease, of which the cause is unknown, was present here. The Division of Agriculture co-operated by bringing photographs of a gall found at Bediako, in the Western Region, to the attention of field staff of swollen shoot virus inspection teams. Since August, 1958 only 44 affected trees have been reported and the galls confirmed as being of a

type similar to the "green-point" gall of South America. The occasional occurrence of galls on cocoa trees in Ghana was first noted by H.A. Dade in 1923 and the incidence of affected trees is apparently no higher now than it was 36 years ago. The position may have been similar in Costa Rica and yet in recent years "cushion gall" disease has reached epidemic proportions there. Because of this, attempts have been made to determine the cause of galls in Ghana.

Transmissions to seedlings were first made by feeding mealybugs (P. njalensis), collected from a gall at Maase in the Eastern Region, on to 5 healthy cocoa beans. Of the seedlings which developed, 3 produced galls from the axillary bud of the cotyledon. Since then further transmissions using P. njalensis and Ferrisiana virgata have been successful both from other galls collected at Maase and from a gall found at Tafo. However, mechanical transmissions without using mealybugs have also been successful. Although the possibility of a virus being the cause has not yet been eliminated it is thought that the most likely pathogen is a bacterium. Bacteria isolated from galls are now under inoculation tests.

ENTOMOLOGY DIVISION

JOINT WACRI/DIVISION OF AGRICULTURE MEALYBUG CONTROL TRIALS

Mealybug studies

The first application of dieldrin treatment has been completed on old plots in the Joint WACRI/Division of Agriculture trial covering Bunso, Bosuso and Osino areas. Second application has been commenced for treatments 1, 2 and 4 (see Q.R. No.54). Fortnightly ant and mealybug population counts are being maintained.

Oyoko Ant/Mealybug Trials

The number of virus infected and contact trees cut out in the treated area has now increased considerably and the encouraging initial results of ant control followed by decline in mealybug population and swollen shoot incidence are not being maintained. The situation is not clear and is being investigated further.

Systemic Insecticides

In all, seven systemic insecticides have now been screened on seedlings through soil, leaf-painting and spray applications. Tasting tests, for occurrence of taint, are being carried out on two of these insecticides.

Leaf Eating Lepidoptera

Routine collecting and rearing of lepidopterous

larvae from cocoa has been continued.

A provisional list of the lepidoptera attacking cocoa at Tafo was given in Quarterly Report No.50. To this list the following species can now be added. The species were identified at the Commonwealth Institute of Entomology.

EUCOSMIDAE

Archips occidentalis Walsm.
Archips sp.

PYRALIDAE

Sylepta retractalis Hmps.

LASIOCAMPIDAE

Leipoxais sp.
Leipoxais rufobrunnea Strand

ACRAEIDAE

Acraea pharsalus Ward
Acraea rogersi Hew.

LYCAENIDAE

Hypolycaena sp.

GEOMETRIDAE

Colocleora divisaria Walk.
Hyposidra smithi Warr.

SYNTOMIDAE

Syntomis dilatoralis Hmps.

ARCTIIDAE

Rodogastria luteibarba Hmps.

NOCTUIDAE

Eudrapa mollis Wlk.

LYMANTRIIDAE

Crorema mentians Walk.
Argyrostagma niobe Weym.
Orgyia mixta Snellen.
Euproctis dewitzi Grunb.
Euproctis sp. nr. *discipuncta* Holl.
Euproctis fasciata Warren.
Euproctis lepidographa Hmps.
Euproctis lyoma Swinh.
Euproctis xanthomelaena Holl.

The following specimens of Limacodids have not yet been sent to the Commonwealth Institute for confirmation of the identification.

LIMACODIDAE

Omocena convergens Hering.
Latoia vitelina Karsch.
Casphalia flavicollis Wlk.
Baria elsa Druce

Unfortunately many specimens were badly damaged in transit to the Commonwealth Institute and some were unrecognisable on arrival there. A further batch of specimens will be despatched, for identification, in the near future.

BOTANY DIVISION

PLANT BREEDING AND SELECTION

Intensive studies of the relationship between growth and yield, mainly in the 9th Progeny Trial, are being made. The following points have been established:-

Positive correlations exist between total yield up to March 1959 in the 9th Progeny Trial, planted 1954, which for the best varieties is in excess of 1 ton per acre, and

1. The exact ages of the trees, which varies by a few months, seed having been sown as the pods ripened.
2. The stem diameters of the seedlings 6 months after planting out.
3. The rate of increase in stem diameter as seedlings as determined from the diameters at (2) above and their ages at that time.
4. The increase in stem diameter between 6 months and 18 months.
5. The diameter attained by July 1959 (at about 5 years old).
6. The geometric mean of the diameters at the first recording and at July 1959. (There was no correlation between the diameters at these two dates).

A reasonable forecast of yield of the varieties could be provided by No.3 ($r = .7$) and 4 ($r = .83$) (Cf. Q.R. 47, p.13).

In broad terms, the varieties commence to bear on attaining a stem diameter of about 6 cm., and as the subsequent build up in yield is rapid the date at which this diameter is attained greatly influences the total yield over these early years. This factor alone could have brought about the existence of these correlations, so that it remains to be proved that the rate of growth of the young seedling will be correlated with the yield performance of mature trees, but rate of growth in early stages may well provide a reliable forecast of subsequent yield performance.

Following the commencement of bearing some varieties have slowed down in vegetative growth while producing relatively heavy yields and others have continued relatively vigorous growth and yielded less heavily, but no variety has slowed in growth to a disturbing extent, and the canopy is now complete and dense over most of the trial.

The diameters of the stems of individual trees in a variety trial usually differ at planting but because the rate of increase of stem diameter is roughly linear, the varieties can be compared on this basis. This technique is being used to compare the varieties in the Series II trials (Q.R. No.52 p.12) and is indicating chiefly a remarkable consistency in the performances of the varieties relative to one another at the various trial sites. It may well be that over the range of conditions covered by these trials the same varieties will be best or near best almost everywhere, in which case the problems of distribution of seed will be greatly simplified.

The stem diameter is only one measure of the size of a plant and hence of growth. The information from the 9th Progeny Trial indicates that the rate of increase in stem diameter is closely related to yield, but none-the-less some caution is needed in its use, for a tree that tends to be tall may possibly have a greater actual size in relation to its stem diameter than one that is shorter, thus a given increase in stem diameter in the former case could mean a greater total increase in size than in the latter case. The use of other criteria of size is therefore being investigated. Increase in height is difficult to make use of because of jorquetting, but increase in the number of leaves may offer an independent criterion against which to test the data on stem diameter increase. For investigations aimed at determining if the performances of the varieties relative to one another varies from site to site, stem diameter increases should be adequate.

CHEMISTRY DIVISION

SOIL FERTILITY

Field experiments

All fertilizer field experiments received their second 1959 nitrogen dressing in September.

The clearing and planting of a 35-acre block for a long-term shade and fertilizer experiment was completed in June. A comprehensive description of the techniques used has been published (Allison and Cunningham, World Crops II 311-313, Sept. 1959).

The 2^4 NPKMg nutritional pot experiment, mentioned in Quarterly Report No.54, has been very successful. To date, the seedlings have been grown for six weeks under full shade and then for periods of four weeks under 75%, 50% and 25% shade, successively. They have now been growing for a further four weeks under full exposure. The pots are set in gravel-filled tanks containing 2 inches of water thus ensuring an adequate supply of water and bamboo side-screens effectively reduce air movement. The previous year's experiment had indicated that insect pests, mainly mole crickets (Gryllotalpa) and Earias biplaga Wlk, adversely affected growth. In this present experiment, satisfactory control was obtained with an initial application of Aldrin to the soil in the pots and bi-weekly spraying with Endrin after the emergence of the seedlings. (The Aldrin concentration was 2 oz. of toxicant per gallon and was applied to the soil with a watering can. The Endrin concentration was 2 oz. of toxicant per gallon and was applied by Misto sprayer to the seedlings and to the bamboo screens).

It was suggested, (Rep. W.Afr. Cocoa Res. Inst. 1958-59) that this technique might be adapted to raising basket seedlings in nurseries. Twelve randomly selected seedlings grown by this new method averaged 48.3 cm. in height, while a comparable batch grown by the standard nursery method averaged 27.3 cm.

Leaf area measurements showed similar trends. Some of the seedlings in the pots received different combinations of N, P, K and Mg, whereas, the nursery seedlings had no applied nutrients. Nevertheless, the improvement in growth by the pot technique is quite spectacular and at the end of five months produces vigorous seedlings which are already "hardened off".

Laboratory work

The soil exposure experiment, which has now been running for $2\frac{1}{2}$ years, was sampled and analysed in September. Three new physical assessments were introduced - total, capillary and non-capillary porosity; water-stable aggregates; compaction of soil.

In the course of studies to investigate the time required for leaching by rain and uptake by plants to remove applied nitrogen from the top six inches of soil, it was discovered that the actual values of mineral nitrogen concentration in the soil were, in the initial stages, lower than the expected values. It was found that, when ammoniacal nitrogenous fertilizers are broadcast on the surface of some cocoa soils, there is an appreciable loss of gaseous ammonia. A fuller

investigation of the problem has been started.

COCOA PREPARATION

Studies have been made of the fermentation of large batches of cocoa by different methods. In particular, investigations of the 'tray' method of fermentation have given much useful information on the effect of varying the batch size and the dimensions of the tray on the quality of the finished cocoa.

Laboratory work, on the factors which affect quality during the processing of raw cocoa, has continued.

I B A D A N S U B - S T A T I O N

VIRUS RESEARCH

Insect Transmission of Nigerian cocoa viruses

Attempts to transmit cocoa necrosis virus (CNV) with various species of insects have continued. Nine to twelve-month-old seedlings cut back to about 8-inch length are now being used as test plants as graft experiments indicate that young plants may not be susceptible to the virus or may not develop symptoms within relatively short periods, as do plants inoculated with cacao swollen shoot virus. No transmissions of CNV have been obtained yet.

Experiments with Nigerian isolates of cacao swollen shoot virus (CSSV) and nymphs of the mealybug species Pseudococcus njalensis Laing and Ferrisiana virgata (Ckll.) taken from infected plants during moulting have so far failed to give transmission of the virus.

The effect of preliminary starvation of mealybugs on transmission of the CSSV isolates from Balogun, Offa Igbo is being studied. So far only a preliminary starvation period of two hours followed by infection feeds of two hours has been adequately tested and unstarved insects transmitted as well as starved ones.

Single P. njalensis nymphs taken from infected plants transmit most frequently during the 45th to 75th minute of test feeding; only few transmissions occur before the 30th and after the 150th minute spent on test beans. Nymphs transferred at intervals to a series of test plants, only rarely infect more than one plant.

Some tests were done to compare the effect on the test plants of infections caused by 10 insects feeding

simultaneously for 24 hours with infections caused by the feeding of 1, 2, 3 and 4 insects respectively on four consecutive days, thus giving a comparable aggregate of ten insect-days. In two tests the effect on growth of the test plants of consecutive tests feeding was more severe than that of simultaneous test feeding, but there was no difference between treatments in three further experiments.

The combined effects of two virulent isolates of cacao swollen shoot virus on the growth of young trees.

In November, 1958, a plot of approximately three hundred young trees was available for experiments at the Agodi cocoa farm near Ibadan. The trees were irregularly spaced, had been planted several years ago and were just coming into bearing, although they had previously been severely damaged by capsids.

The trees were measured, and the best 240 divided into twenty four groups, each of which contained the same number of each size and condition. Twelve groups were retained as controls and the rest were grafted in December with bark patches from plants containing unrelated virulent isolates from Abaku and Egbeda. All the new shoots on the trees in six of the inoculated groups and six of the controls have been damaged, by nipping them with pliers to simulate capsid damage. This has been repeated at fortnightly intervals since June 1959.

In July, 1959, the records of stem diameters showed that the inoculated plants had made significantly less growth than the controls in the seven months following the inoculations. In that time most of the inoculated trees had shown the conspicuous leaf symptoms of both isolates and the swellings caused by the one from Egbeda. Counts made in July and August showed that virus also had a severe effect on flushing. Compared with the healthy controls the number of new shoots was decreased by 60% in July, and by 80% in August, when all the trees were making less growth. Many of the inoculated trees bore large swellings on the tips of the branches, and in such instances extension growth was often completely stopped by death of the terminal bud.

The effect of a Nigerian virus isolate on young cocoa in the field.

In November 360 plants growing in the guard rows of another experiment planted earlier in the year were selected for their uniform size and used for a subsidiary experiment: One third of the seedlings, chosen at random, were retained as healthy controls, and the remaining seedlings were graft-inoculated with the virulent isolate of cacao swollen shoot

virus from Egbeda. Half the inoculations were done in November, 1958 (T1) and the rest in February, 1959 (T2), when most of the plants inoculated at T1 were already showing symptoms.

Routine observations were made on leaf number, stem diameter, stem height and on the appearance of symptoms. Furthermore, half the plants in each group were carefully uprooted in July, 1959, and carried to the laboratory for examination. Records were then made of the number of lateral roots and also of the air dry weights of stem, tap root and lateral root. By May, 1959, the plants inoculated with virus had made significantly less growth than the controls (Table 1).

TABLE 1

The Effects of a Virulent Isolate of Swollen Shoot Virus on the Growth of Young Cacao in the Field

Category	Mean Stem Diameter May 1959 cm.	Mean Stem Diameter Sept. 1959 cm.	Mean Leaf Number*	Mean Stem Height cm.	Mean Number of Stem Swellings*	Percentage Leaves with Symptom*
Healthy Controls	1.5	2.5	47	140	Nil	Nil
Inoculated at T1 (Nov.1958)	1.3	1.9	33	112	3	5.8
Inoculated at T2 (Feb.1959)	1.4	2.0	37	128	2	21.7

* Observations made in May, 1959.

The earliest inoculations had the greatest effect and in the six months from T1, the stems of infected plants grew at the mean rate of 7.6 cm. per month, compared with 10.4 cm. for the plants inoculated at T2 and 12.9 cm. for the controls. The effects on leaf number and stem diameter were similar.

The results for the sample of trees uprooted and weighed in July 1959 showed that virus caused a general stunting with similar effects on the weights of all the organs considered (Table 2).

TABLE 2

The Effect of Virulent Isolate of Swollen Shoot Virus on Stem and Root Growth*

Category	Mean Weight (g.)				Stem/ Root Ratio	Tap/Lateral Root Ratio	Mean Number of Lateral Roots
	Stem	Tap Root	Lateral Root	Total Root			
Healthy Controls	248	74	16	90	2.8	5.6	39
Inoculated at T1 (Nov.1958)	174	53	11	64	2.7	4.8	37
Inoculated at T2 (Feb.1958)	195	62	11	73	2.7	5.6	37

* Young basket grown seedlings were planted in the field in July 1958 and sample was harvested in July, 1959.

There was no change in the stem/root ratio, nor any increase in the ratio of tap to lateral root. Indeed, there was no marked decrease in the number of lateral roots and no evidence to indicate that the effect of virus is due to death of the finer roots. This has been suggested for the most virulent strains in Ghana, with supporting evidence from very young seedlings infected in the laboratory (Goodall, Ann. appl. Biol. 36, 440, 1949).

The symptoms on the inoculated plants in the field followed the characteristic sequence previously noted in the insectaries:

A preliminary phase of limited leaf symptoms was followed by an acute phase of infection, with crinkling and abscission of many immature leaves and a conspicuous interveinal chlorosis of those which remained. Conspicuous swellings appeared at this stage and subsequently. Later there was a prolonged chronic phase of infection with limited vein banding symptoms on a small proportion of the leaves.

Detailed observations were made in May, 1959, when most of the plants inoculated at T1 had already passed into the chronic phase of infection. Most of them bore only a few leaves with symptoms, although swellings were common. By comparison, the plants inoculated at T2 had fewer swellings, but a large proportion of the leaves showed leaf symptoms, many of them of the severe type characteristic of the acute phase (Table 2).

BLACK POD CONTROL:

Laboratory Studies:

The techniques described in Rep. W. Afr. Cocoa Res. Inst. 1958-59 have been somewhat modified. A reservoir has been placed between the air pump and the spray nozzle to eliminate pressure changes which caused variations in the emission rate. Zoospore suspensions of Phytophthora palmivora (Butl.) Butl. are now produced in an air conditioned room where the lower temperatures appear to favour zoospore liberation.

At between 68-70°F the zoospores remain actively motile and they do not germinate as rapidly as at 80°F. The concentration of zoospores in the filtered suspension is estimated from a sample by fixing with osmic acid vapour and then counting them in a Fuch - Rosenthal blood counting cell. Suspensions are then diluted as necessary to give a standard concentration of about 200,000 per ml. for spraying onto pods.

Pre-spray treatments for pods have been re-examined. Pods enclosed in Polythene bags soon after collection, and cooled overnight gave the most consistent results. In the latest experiments the mean number of spots per pod was 53.7 and the standard deviation 7.8. Cooling for shorter periods gave a slightly higher but more variable numbers of spots.

The use of a proprietary cuprous oxide formulation as a standard in all the laboratory fungicide tests has been abandoned. Standard laboratory Bordeaux Mixture, prepared according to the recommendations of the American Phytopathological Societies' Committee on standardization of fungicide tests is now used in its place.

Using this standard a number of fungicides have been re-examined for their initial toxicity according to the methods outlined in the Annual Report. Once again the results suggest that the three copper oxychloride formulations examined were inferior to three cuprous oxide formulations when applied at the same concentration of copper. In all cases the differences were significant at 0.1%. An analysis of variance is applied to the spot number counts after the transformation $X = \sqrt{(X + 1)}$ has been made. The Duncan multiple range test (Biometrics II, 1-42, 1955) is applied to examine the significance of the means. Standard laboratory Bordeaux Mixture would appear to be the best fungicide so far examined. It must be remembered that these tests do not take into consideration the weathering properties of the various formulations.

A preliminary experiment, using an improvised settling tower fitted with a spray nozzle from a hand atomizer suggests that it will be feasible to use a slide germination technique

to estimate the efficiency of a number of fungicides suitable for black pod control. An exploratory calibration of the deposits obtained on glass slides in the settling tower was made using Analine Blue dye, the colour being measured in an absorptiometer. Although the uniformity of the deposits was good (considerably better than that on pod surfaces using the horizontal sprayer) a final calibration will not be made until a new nozzle can be fitted.

Further tests suggest that zoospores of P. palmivora will fulfil all the requirements of a test organism suggested by M^{c}Callan et. al. (Contr. Boyce Thompson Inst. 12, 49-77, 1941) except that they are not very easily countable. Sporangia are not suitable because of the difficulty of producing larger numbers under controlled conditions, and because the percentage germination after 20 hours is often poor.

Provided that the physical difficulties of this technique can be overcome it is hoped that the results will corroborate those obtained by the pod spraying method.

Field Studies:

At the request of the Department of Agriculture a field trial is being conducted at Owena, Ondo Province, to compare the efficiency of three proprietary cuprous oxide formulations and Carbide Bordeaux Mixture for the control of black pod disease. The experiment is laid down in the form of a randomized block with ten replicates of each treatment. Each plot contains 20 trees. There are no unsprayed controls the Carbide Bordeaux plots being taken as a standard. Records are kept of the numbers of healthy and diseased pods removed at each harvesting date. The cuprous oxide formulations are each applied at a concentration of 0.4% and the Carbide Bordeaux at a concentration of 1% which are the concentrations recommended by the Ministry of Agriculture and Natural Resources, Western Region, for farmers use.

All the fungicides are applied from pneumatic knapsack sprayer fitted with the nozzles recommended to farmers as being suitable for black pod control spraying.

Harvesting and recording commenced on May 20th and spraying on May 21st., and have since been carried out at 3 weekly intervals. At the time of writing the main crop is beginning to ripen and after the recent heavy rains black pods are common on all plots.

STUDIES ON DIE-BACK OF COCOA: (D. KAY)

The spread of lesions, made by inserting a needle contaminated with spores of Calonectria rigidiuscula (Berk & Br.)

Sacc. into Amelonado cocoa seedlings has been studied in Ghana. The rate of spread and development of the lesions was similar to that observed under Nigerian conditions (Rep. W. Afr. Cocoa Res. Inst. 1958-59) and greater than that previously reported from Ghana by Owen (Ann. appl. Biol. 44, 307-321, 1956). Under similar conditions a Ghanaian isolate of C. rigidiuscula spread slightly more rapidly in cocoa tissue than a Nigerian isolate, but the difference was not significant. Significant increases in the rate of spread of the fungus were found when the host seedlings were grown under shade in contrast to full sunlight and in seedlings receiving infrequent watering when compared with those watered daily.

The effects of the presence or absence of cacao swollen shoot virus on the development and spread of die-back was studied on mature Amelonado cocoa trees. The percentage of twigs infected with C. rigidiuscula which subsequently died was higher when the virus was present. The mean percentage of deaths in four separate experiments involving a total of eighty trees and nearly 2,000 infected twigs is given below:-

	1 Week	2 Weeks	4 Weeks	8 Weeks
Non Virus Trees	5.6%	10.1%	13.6%	18.2%
Virus Infected Trees	8.6%	15.2%	22.4%	28.0%

Furthermore, there was an indication that the percentage of deaths in virus infected trees was greater during the acute stage of virus infection than in the subsequent chronic stage.

The presence or absence of virus infection does not consistently affect the rate of spread of die-back. This spread was usually approximately the same or only slightly greater in virus infected trees than in trees without virus infection.

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